VIA ELECTRONIC DELIVERY

December 22, 2015

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, SW
Room TWA325
Washington, DC 20554

Re: ***Ex Parte* Notice**
ET Docket No. 13-49, *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*

Dear Ms. Dortch:

The Alliance of Automobile Manufacturers ("Alliance"),[1] the Association of Global Automakers ("Global Automakers"),[2] Cisco Systems, Inc. ("Cisco"), and DENSO International America, Inc. ("DENSO") submit this *ex parte* letter to update the Commission on their testing of proposals for sharing between primary Dedicated Short Range Communications ("DSRC") and unlicensed operations in the 5850-5925 MHz ("5.9 GHz") band. In particular, this letter reports the results of initial "proof of concept" testing of the enhanced Clear Channel Assessment, or "Listen, Detect, and Avoid" protocol ("Cisco Proposal"). We continue to believe that sharing between primary DSRC and unlicensed operations in the 5.9 GHz band may be possible and to engage extensively with other stakeholders to develop an industry-led sharing solution.

On May 6, 2015, the Alliance, Global Automakers, and Cisco reported that an initial round of feasibility tests of the Cisco Proposal would begin soon and be completed before the end of the calendar year,[3] with additional feasibility tests possible in 2016. We also explained that the results of the tests would provide the Commission with empirical evidence to determine

[1] The Alliance is an association of twelve of the world's leading car and light truck manufacturers, including BMW Group, Chrysler Group LLC, Ford Motor Company, General Motors Company, Jaguar, Land Rover, Mazda, Mercedes-Benz USA, Mitsubishi Motors, Porsche, Toyota, Volkswagen Group of America, and Volvo Cars. *See* Alliance of Automobile Manufacturers, Members, http://www.autoalliance.org/about-the-alliance/overview.

[2] Global Automakers represents international motor vehicle manufacturers, original equipment suppliers, and other automotive-related trade associations. Its members include American Honda Motor Co., Aston Martin Lagonda of North America, Inc., Ferrari North America, Inc., Hyundai Motor America, lsuzu Motors America, Inc., Kia Motors America, Inc., Maserati North America, Inc., McLaren Automotive Ltd., Nissan North America, Inc., Subaru of America, Inc., Suzuki Motor of America, Inc., Toyota Motor North America, Inc., ADVICS North America, Inc., Delphi Corporation, Denso International America, Inc., Sirius XM Radio, Inc., and Robert Bosch Corporation. *See* Global Automakers, Members, http://www.globalautomakers.org/members.

[3] *See* Letter from Frederick M. Joyce, Counsel for Global Automakers, *et al.*, to Marlene H. Dortch, Secretary, FCC, ET Docket No. 13-49 (filed May 6, 2015).

whether this technology has the technical capability to foster unlicensed Wi-Fi use of the 5.9 GHz band without causing harmful interference to incumbent DSRC operations.[4]

These efforts are consistent with the approach recommended by members of Congress and industry stakeholders in recent letters to the FCC and the National Highway Traffic Safety Administration ("NHTSA"), which urged the adoption of certain principles for testing 5.9 GHz unlicensed sharing proposals. On September 9, 2015, a bi-partisan group of senators from the U.S. Senate Committee on Commerce, Science, and Transportation endorsed specific principles and goals for determining whether sharing proposals cause harmful interference to incumbents in the 5.9 GHz band.[5] On that same day, a broad coalition of automakers, satellite providers, cable companies, unlicensed spectrum advocates, and wireless technology companies endorsed the same principles and goals.[6]

The initial round of testing at Cisco consisted of two parts. First, Cisco developed the V2X detector portion of its mitigation equipment.[7] It contracted with Mango Communications ("Mango") to create three software defined radios based on the WARP v3 platform. Each WARP v3 can also be operated as four DSRC 802.11p detectors on channels 172, 174, 176 and 178.[8] Second, Cisco calibrated the equipment by measuring between two Mango systems (one operating as a DSRC transmitter and the other operating as a DSRC detector) and with a third-party DSRC radio to verify that the detector was performing as expected.[9] In further testing at DENSO's lab, a programmable signal generator provided a V2X-compliant packet stream to the WARP detector inside a shield box, which logged packet detection activity on DSRC Channels 172, 174, 176, and 178.[10]

These tests demonstrated reliable detection of V2X signals at DSRC signal levels down to -95 dBm, as independently evaluated on DSRC Channels 172, 174, 176, and 178, as described in further detail in the attached document.[11] The tests also demonstrated a detection response time of about 8 microseconds.[12]

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[4] *See id.* at 2.

[5] *See* Letter from Rep. John Thune, Chairman, U.S. Senate Committee on Commerce, Science, and Transportation, *et al.*, to Tom Wheeler, Chairman, FCC, *et al.* (dated Sept. 9, 2015), *available at* http://1.usa.gov/1MfoObP.

[6] *See* Letter from the Alliance *et al.*, to Tom Wheeler, Chairman, FCC, *et al.* (dated Sept. 9, 2015), *available at* http://bit.ly/207Ly8j.

[7] *See* Attach. at 2-3.

[8] *See id.*

[9] *See id.* at 3.

[10] *See id.* at 4-6. Detection was, as anticipated, not reliable on Channel 180 and not possible on Channels 182 and 184. *See id.*

[11] *See id.* at 5.

[12] *See id.* at 6.

Further work – to include development of Wi-Fi devices equipped with interference mitigation that can operate above 5850 MHz – will enable lab testing with both Wi-Fi transmitters and V2X transceivers on the same channel.[13] This will enable an initial evaluation of the full detect and vacate functions. We will continue to update the Commission on the results of device development and further testing.

Pursuant to Section 1.206(b)(2) of the Commission's rules, an electronic copy of this letter is being filed for inclusion in the above-referenced docket.

Respectfully submitted,

*_/s/ Ari Q. Fitzgerald_*
Ari Q. Fitzgerald
Partner
Hogan Lovells US LLP
Counsel to the Alliance of Automobile Manufacturers
Ari.Fitzgerald@hoganlovells.com
D +1 202 637 5423

/s/ James Arden Barnett, Jr.
James Arden Barnett, Jr.
Rear Admiral USN (Retired)
Partner, Venable LLP
Counsel to the Association of
Global Automakers
jbarnett@venable.com
D +1 202 344 4695

*_/s/ Mary Brown_*
Mary Brown
Senior Director, Government Affairs
Cisco Systems, Inc.
marybrow@cisco.com
D +1 202 354 2923

*_/s/ Terry L. Helgesen_*
Terry L. Helgesen
Senior Vice President
DENSO International America, Inc.
terry_helgesen@denso-diam.com
D +1 248 372 8550

[13] *See id.* at 6-7.

Attachment

Ex Parte in ET Docket No. 13-49, ***Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band***

The following document provides a description of development work done to date by Cisco and lab testing with DENSO to evaluate the detector portion of mitigation equipment that would be necessary for Wi-Fi devices to successfully share the 5850-5925 MHz ITS band (ITS Band). The document consists of two parts: background and description of the problem and testing work completed to date.

I. Background

Cisco is developing a Dedicated Short Range Communications (DSRC) spectrum sharing solution[1] based on a "Detect & Vacate" (D&V) approach. The testing goal is to evaluate Cisco's proposed mitigation approach for Wi-Fi use of the ITS Band, assuming: DSRC technology is deployed in vehicles and infrastructure and will continue to be treated as a primary user of the ITS Band; and Wi-Fi, as an unlicensed transmitter, must not create harmful interference to DSRC transmissions. DSRC, which includes a safety of life mission, must be able to continue to function as designed and tested.[2]

Task Plan: The plan to evaluate the proposed approach for Wi-Fi sharing includes:

- Development of mitigation equipment
- Equipment calibration
- Testing of the 4-channel detection function
- Development of prototype D&V equipment in the ITS Band
- Testing of prototype D&V Wi-Fi equipment in the ITS Band
- Further testing by government entities

Cisco Mitigation Concept: As a preliminary matter, Wi-Fi use of the spectrum, up to 5895 MHz, would provide significant new bandwidth for IEEE 802.11ac Wi-Fi devices that use 80 MHz-wide or 160 MHz-wide channels. Current Wi-Fi technology is not permitted to operate above 5850 MHz. Should Wi-Fi be permitted to operate in the ITS Band, its channelization would be different and larger than that of DSRC devices. IEEE 802.11ac is optimized to perform using 80 MHz-wide or 160 MHz-wide channels, although it is backward compatible to transmit on 40 MHz-wide or 20 MHz-wide channels. DSRC devices in the ITS Band, by contrast, transmit on 10 MHz-wide channels. As a result, the Wi-Fi mitigation must be able to detect and protect transmissions on 10 MHz-wide channels, which existing Wi-Fi technology cannot. In addition to detecting DSRC operating on narrower channels, the Wi-Fi transmitter using the ITS Band must be able to cease transmissions in that band (at a minimum) and ideally move the Wi-Fi communications to other 5 GHz spectrum available for Wi-Fi use so that network traffic can continue. Finally, detection must be reliable enough to avoid interfering with safety critical messaging, including

[1] We are using DSRC as it is defined in 47 C.F.R. Parts 90 and 95.

[2] Any technology can employ 10 MHz DSRC detectors. Cisco does not intend to exclude other unlicensed technologies, but, given the size of the Wi-Fi ecosystem and the parties' mutual interest, Wi-Fi technology appeared to be the best place to start the examination. Cisco also is not ignoring how Wi-Fi might impact satellite transmissions. Assuming sharing with DSRC can be solved to stakeholders' satisfaction, the next step would be to consider satellite sharing issues.

messaging over the DSRC V2V channel. Cisco proposes that Wi-Fi mitigation technology detect DSRC preambles and vacate the channel before the next Wi-Fi frame is transmitted.

These concepts align with the National Telecommunications and Information Administration's (NTIA) 2013 views on how spectrum sharing might be possible:

> **Matched Filter Detection.** Threshold detection, in conjunction with matched filter technology, is currently being used to improve the detection capabilities for sharing between U-NII devices employing digital modulation formats. The well-defined signal parameters associated with the U-NII device data transmissions enhance matched filter performance.[3]

II. Development of Mitigation & Test Status

A. Development of Mitigation Equipment

Cisco contracted with Mango Communications for hardware and software development on the WARP v3 kit[4] and received three Software Defined Radios, each with two 40 MHz radio interfaces based on the Maxim MAX2829 transceiver chip. Each radio interface is specified to operate in the 2.4-2.5 GHz band and the 4.9- 5.875 GHz band. Although the chip band limit is 5.875 GHz, the transceiver functions to 5.895 GHz and is useful in the testing. The radio frequency chip design is about seven years old, and is representative of good 802.11g/a radios.

Each of the WARP v3 devices can be operated as a DSRC transmitter that sends 802.11p waveforms on channels 172, 174, 176 and 178. The DSRC and U-NII channel designations are shown in the following chart.

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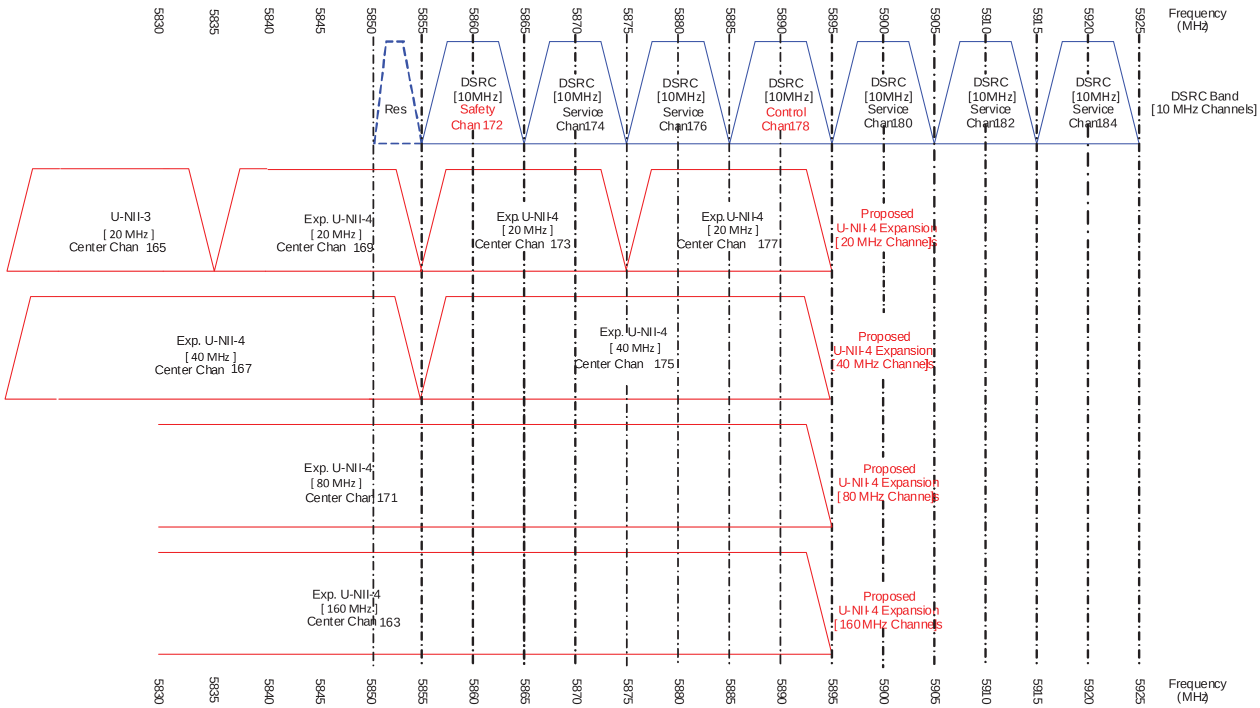
[3] Evaluation of the 5350-5470 MHz and 5850-5925 MHz bands pursuant to Section 6406(b) of the Middle Class Tax Relief and Job Creation Act of 2012, NTIA Report to Congress, published January 25, 2013, *available at* http://www.ntia.doc.gov/report/2013/evaluation-5350-5470-mhz-and-5850-5925-mhz-bands.

[4] *See* Mango Communications, Warp v3 Kit, http://mangocomm.com/products/kits/warp-v3-kit (last visited Dec. 22, 2015).

Figure 1



The software allows each of the WARP v3 devices to be operated as four DSRC 802.11p detectors on 10 MHz channels 172, 174, 176 and 178. If a DSRC 802.11p preamble is detected, then hardware asserts DSRC detection.

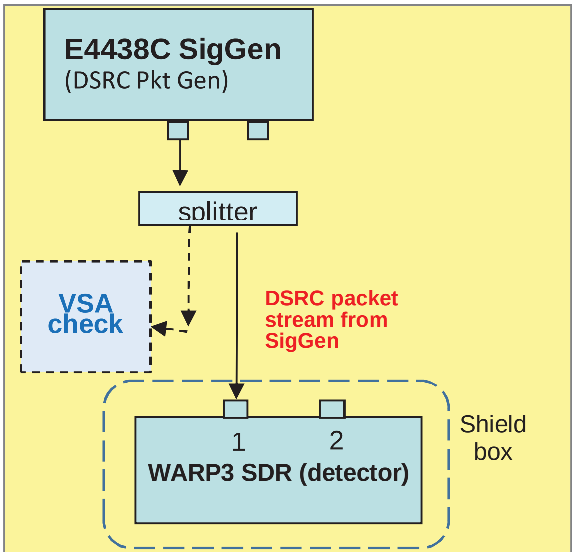
B. Equipment Checkout

Before testing at DENSO, Cisco measured DSRC packet detection in its lab using one of the Mango systems as a DSRC detector. In one test a second Mango system was configured as a DSRC transmitter, and in another test a third-party DSRC radio was used as a DSRC transmitter.

C. Testing the 4-Channel Detection Function

Detection Test Setup. The figure below shows the setup at DENSO for measuring the Cisco DSRC 4-channel detector. A programmable signal generator provided an 802.11p-compliant packet stream to the WARP v3 DSRC 802.11p detector inside a shield box, which logged packet activity on channels 172, 174, 176 and 178. The generator was used in DENSO testing because it provides accurate output power down to -100dBm, and can be switched across the DSRC channels of interest. The logs were observed to verify detector operation on the various DSRC channels. An immediate visual indication of detection was also given by an LED on the transceiver.

Figure 2



The WARP3 4-channel detector triggers an LED and logs DSRC preamble detections.

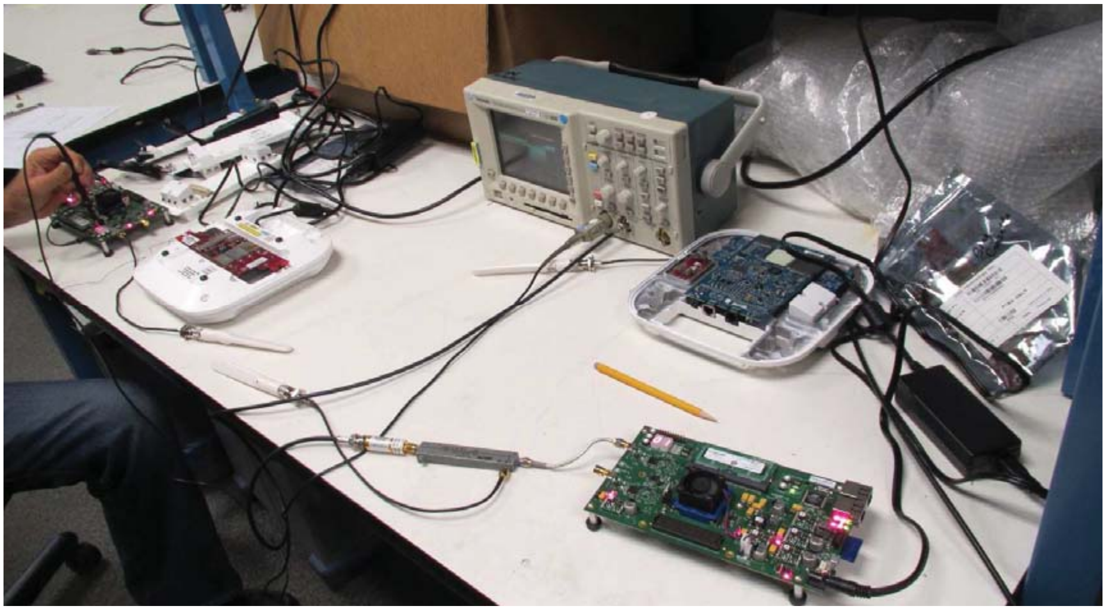
Detection Test Results. The table below shows the first results of testing of the 4-channel DSRC detector. The cabled tests demonstrated reliable detection of DSRC signals at signal levels (RSS) down to -95 dBm/10 MHz. DSRC signals on the 4 lower channels were applied independently to the detector.

Figure 3

DSRC RSS	**Yes/No Detection result by V2X Channel**			
LEVELS, dBm	172	174	176	178
-30	Y	Y	Y	Y
-40	Y	Y	Y	Y
-50	Y	Y	Y	Y
-60	Y	Y	Y	Y
-70	Y	Y	Y	Y
-80	Y	Y	Y	Y
-85	Y	Y	Y	Y
-86	Y	Y	Y	Y
-87	Y	Y	Y	Y
-88	Y	Y	Y	Y
-89	Y	Y	Y	Y
-90	Y	Y	Y	Y
-91	Y	Y	Y	Y
-92	Y	Y	Y	Y
-93	Y	Y	Y	Y
-94	Y	Y	Y	Y
-95	Y	Y	Y	Y
-96				
-97	progressively less detection			
-98				

Detection Trigger Delay. Cisco subsequently measured WARP v3 DSRC 802.11p detection delay with a setup shown in Photo 1 below.

Photo 1



The left WARP v3 (circuit board) is the DSRC 802.11p detector, and the right WARP v3 is the DSRC 802.11p transmitter, shown transmitting one 802.11p frame preamble per second on channel 172.

Photo 2 shows the measured detection response time of about eight microseconds, calculated from the start of the packet preamble (to the right of the vertical line that splits the display in half) to the moment that detection occurs (when the yellow trace transitions from low to high). The blue trace is an inverted view of the DSRC transmitter output, showing the transmitted packet header in the wide shaded area. Note that the beginning of the packet preamble is aligned with the center vertical line.

Photo 2

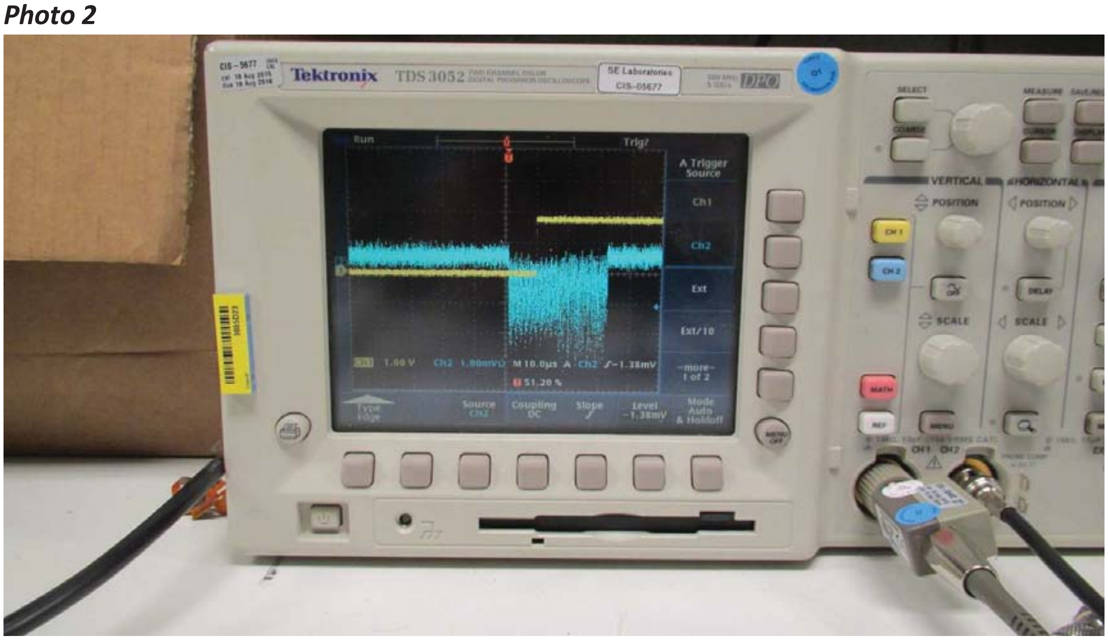


Figure 4 below shows the timing for the preamble structure at the beginning of an 802.11p frame, represented by the part of the blue trace nearest the center line in Photo 2.

Figure 4

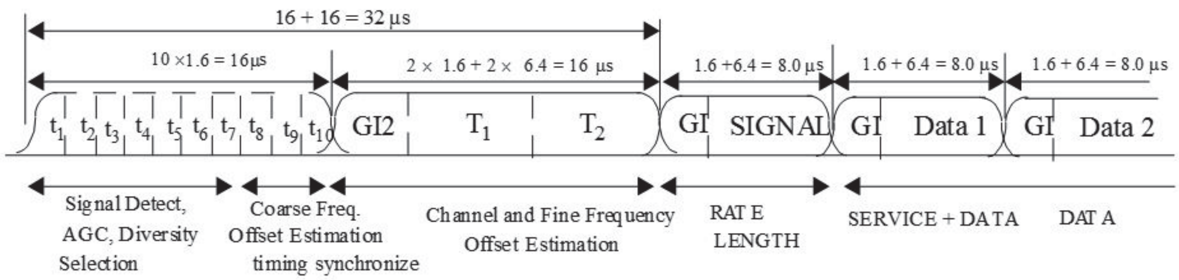


Figure 4 shows the 10 MHz OFDM training structure (PLCP preamble), where t1 to t10 denote short training symbols and T1 and T2 denote long training symbols. The total training length is 32 µs. The PLCP preamble is followed by the SIGNAL field and DATA.

D. Development of Prototype D&V Wi-Fi Equipment in the 5850-5925 MHz ITS Band

Further work – to include development of Wi-Fi devices equipped with mitigation that transmit above 5850 MHz – will enable lab testing with both Wi-Fi transmitters and DSRC transceivers on the same channel. This will enable the evaluation of not only the detection function but also the vacate function. If the lab tests are promising, then simple road tests can be performed next. Assuming further progress, testing by government entities can be conducted.

E. Summary

Cisco is developing a DSRC spectrum sharing solution based on a “Detect & Vacate” (D&V) approach. It contracted for the hardware and software development of transceivers that could operate as a 4-channel DSRC detector in order to test the detection methodology of the D&V approach. Detection was tested in a cabled setup with DSRC-compliant packets independently on channels 172, 174, 176, and 178. It reliably detected those packets at signal levels down to -95dBm/10 MHz. This is the signal level at which many DSRC radios detect other DSRC transmissions. In addition, the detector delay was measured and indicated it could detect the presence of DSRC packets only 8 microseconds after the start of the packet.